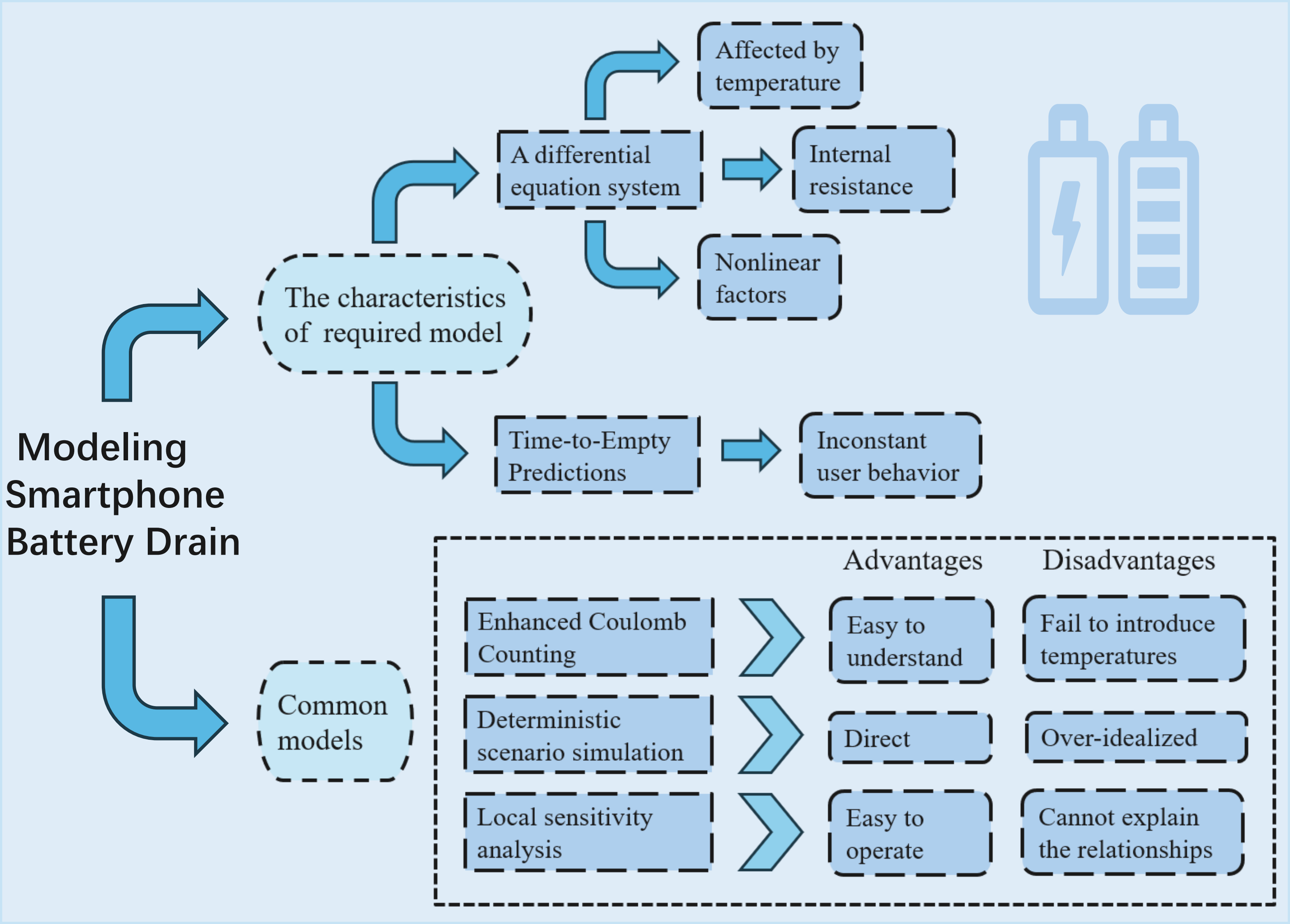
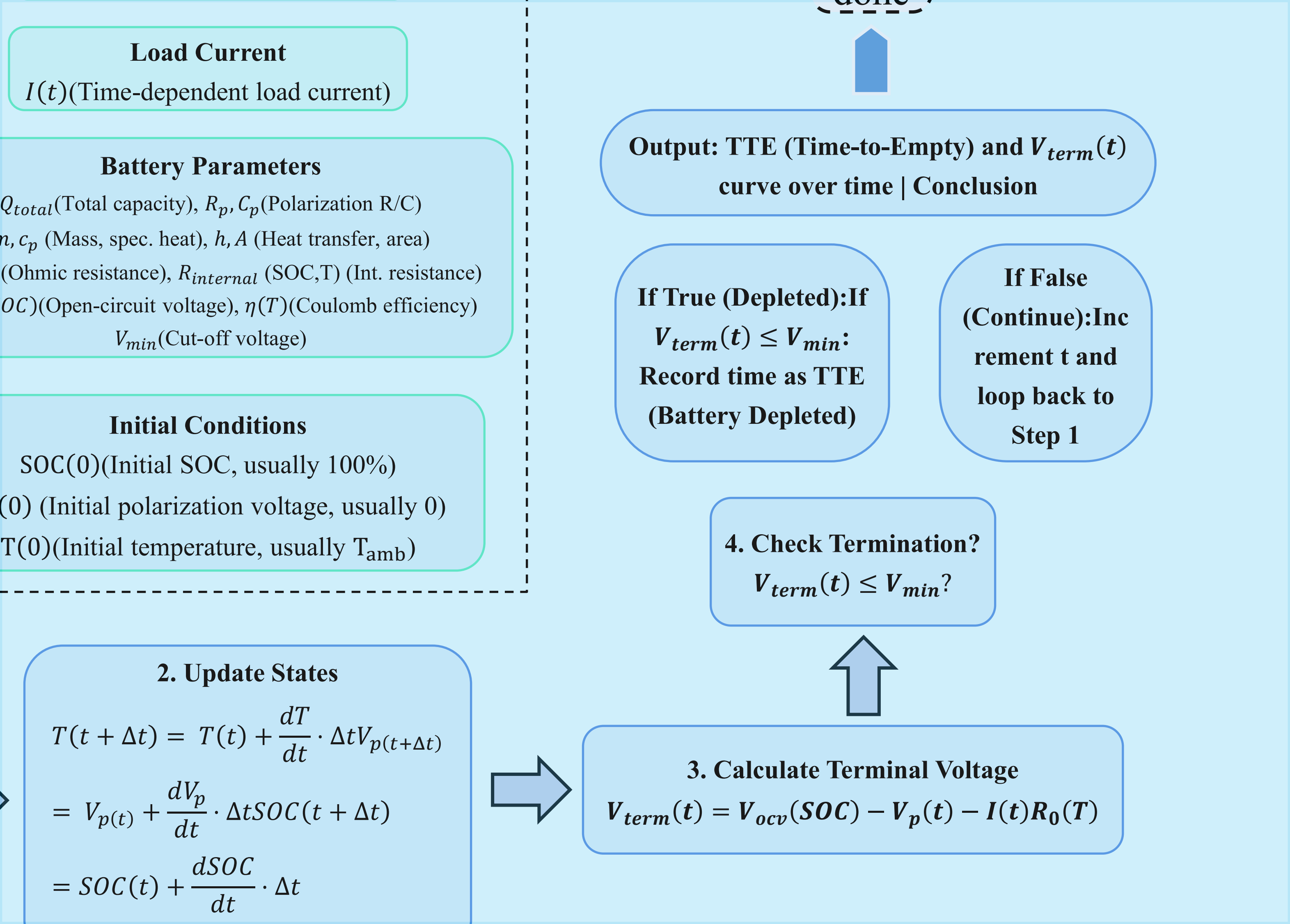


Modeling Smartphone Battery Drain
The characteristics of required model
A differential equation system
Affected by temperature
Internal resistance
Nonlinear factors
Time-to-Empty Predictions
Inconstant user behavior
Common models
Advantages
Disadvantages
Enhanced Coulomb Counting
Easy to understand
Fail to introduce temperatures
Deterministic scenario simulation
Direct
Over-idealized
Local sensitivity analysis
Easy to operate
Cannot explain the relationships


Load Current
$I(t)$(Time-dependent load current)
Battery Parameters
Q_{total}(Total capacity), R_p, C_p(Polarization R/C)
n, c_p (Mass, spec. heat), h, A (Heat transfer, area)
(Ohmic resistance), $R_{internal}$ (SOC,T) (Int. resistance)
$OC)$(Open-circuit voltage), $\eta(T)$(Coulomb efficiency)
V_{min}(Cut-off voltage)
Initial Conditions
SOC(0)(Initial SOC, usually 100%)
(0) (Initial polarization voltage, usually 0)
T(0)(Initial temperature, usually T_{amb})
2. Update States
$T(t+\Delta t) = T(t) + \frac{dT}{dt} \cdot \Delta t V_{p(t+\Delta t)}$
$= V_{p(t)} + \frac{dV_p}{dt} \cdot \Delta t SOC(t+\Delta t)$
$= SOC(t) + \frac{dSOC}{dt} \cdot \Delta t$
3. Calculate Terminal Voltage
$V_{term}(t) = V_{ocv}(SOC) - V_p(t) - I(t)R_0(T)$
4. Check Termination?
$V_{term}(t) \leq V_{min}$?
If True (Depleted):If $V_{term}(t) \leq V_{min}$: Record time as TTE (Battery Depleted)
If False (Continue):Increment t and loop back to Step 1
Output: TTE (Time-to-Empty) and $V_{term}(t)$ curve over time | Conclusion